

SmartSwitch - SD1201

ECE 405: Senior Design 3

SD1201

NSF

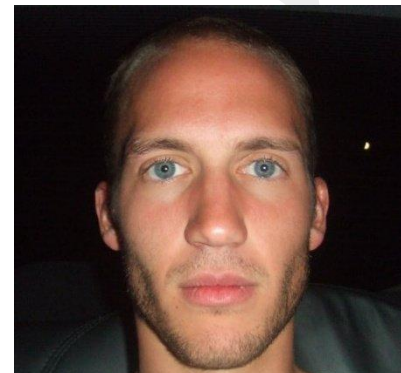


Jake Joraanstad, Ben Whittier,
Joe O'Donnell, and Darren Stewart
Advisor: Dr. Roger Green



The SmartSwitch Team

- Jake Joraanstad
 - Computer engineering background,
 - Founder at Myriad Devices
 - An expert in mobile technology
- Ben Whittier
 - Electrical engineering major
 - Hardware design experience at Phoenix Int'l, a John Deere Company
 - Working at Seagate Technologies after graduation
- Joe O'Donnell
 - CmprE major, minor in CSci
 - Working at John Deere Electronic Solutions after graduation.
- Darren Stewart
 - EE student, Math minor
 - Endless possibilities



Introduction: The Problem

Making your home mobile

- Increasing energy costs
- No logistics information

Contemporary energy monitoring and control systems are:

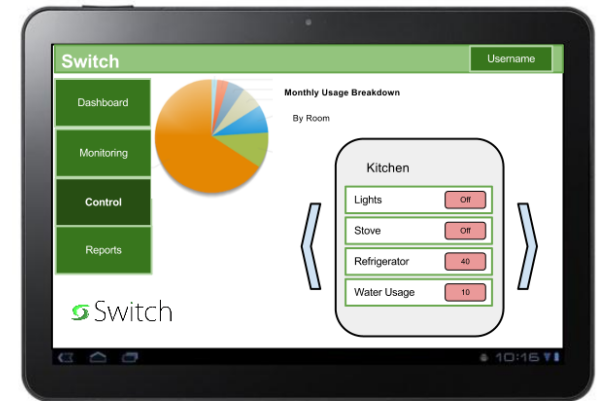
- Proprietary and Expensive
- Limited
 - Purposefully keep out external hardware manufacturers
- Old Technology
 - Not Wireless IP based
 - Not utilizing mobile and web technologies
- NOT user-friendly



Introduction: Our Goal

To create a wireless electronic switch that can simply and cost-effectively monitor electrical current consumption and intelligently maintain power consumption data, report the length of time a device is consuming electrical current, generate an analysis, and send the information directly to a website for easy access.

Lastly, we wanted to allow a user to control this device from anywhere in the world from their smartphone, tablet, or the web.

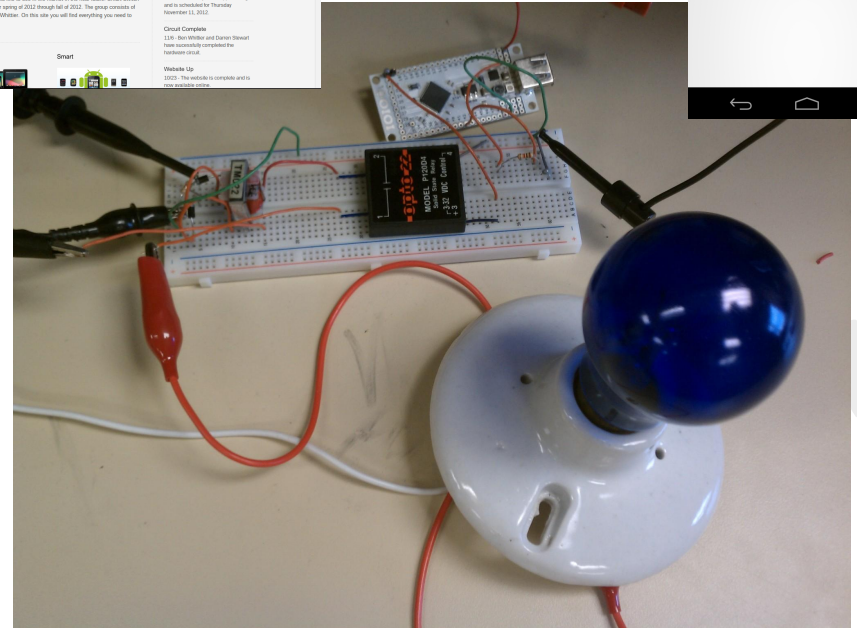
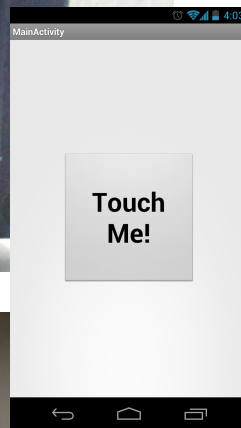
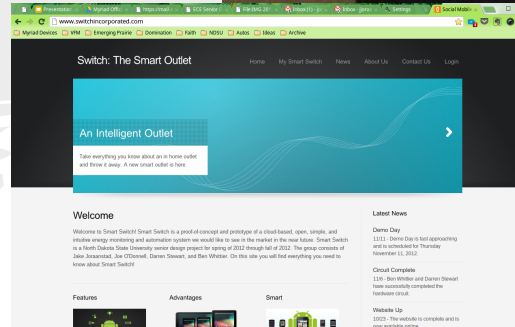


Introduction: The SmartSwitch

An easy to use
"smart" outlet

Controlled from
anywhere with a
smartphone or
from the web

Energy and Usage
Monitoring capabilities





Requirements

Requirements

Project Objectives

- For hardware:
 - On/off control
 - Power monitoring signal being supplied to the micro
 - Temperature monitoring
 - An enclosure fully housing our components
 - All our electrical components on a fully functional PCB
- Software will have the following:
 - An app running on the local phone that controls the functionality and displays power data
 - This app will also send data to the cloud with status
 - Remote control of the functionality from a secondary phone or browser using Wi-Fi
 - A website displaying power consumption data

Requirements: National Science Foundation

SmartSwitch provides persons with physical limitations options to:

1. Monitor and control electrical devices in his/her home from a mobile device
2. Save energy in the home without having to deal with the stresses of moving around the house

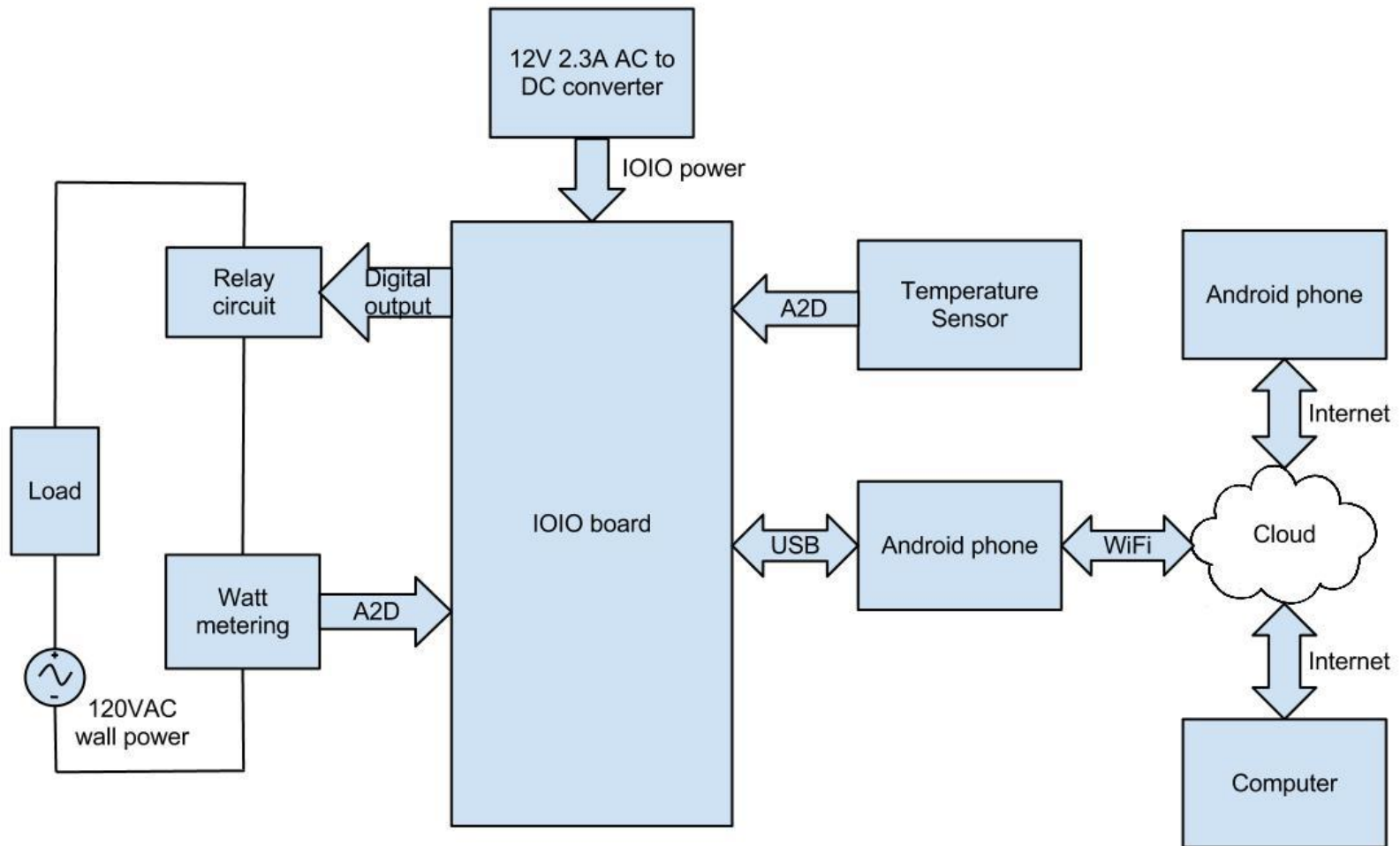
In Addition, Smart Switch could:

1. Enable an assisted living provider to monitor and control devices in the rooms of its residents
2. Easily be expandable to have added functionalities for other sensors/controls with a minimal added cost or redesign necessary



Technical Work

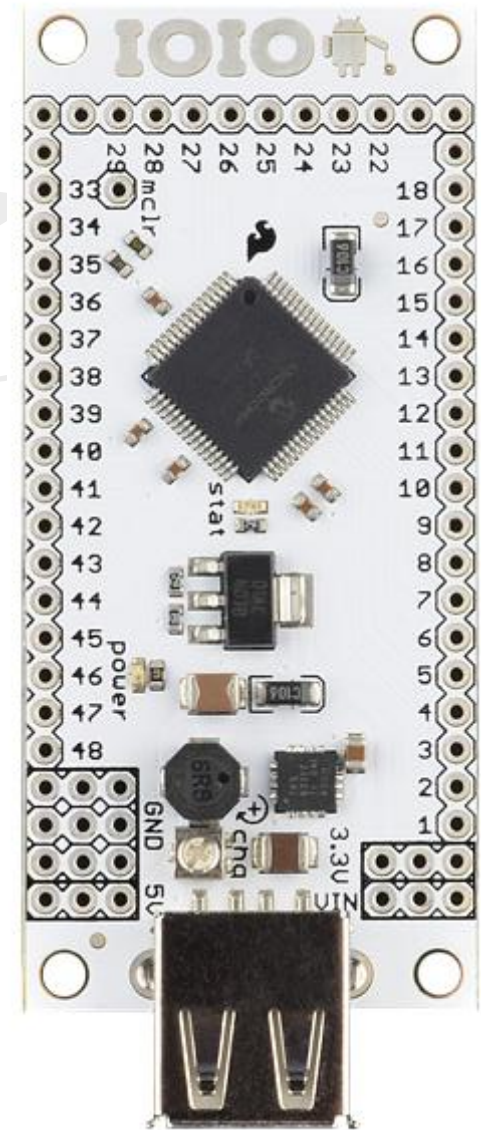
Block Diagram of SmartSwitch



Hardware - Design Considerations

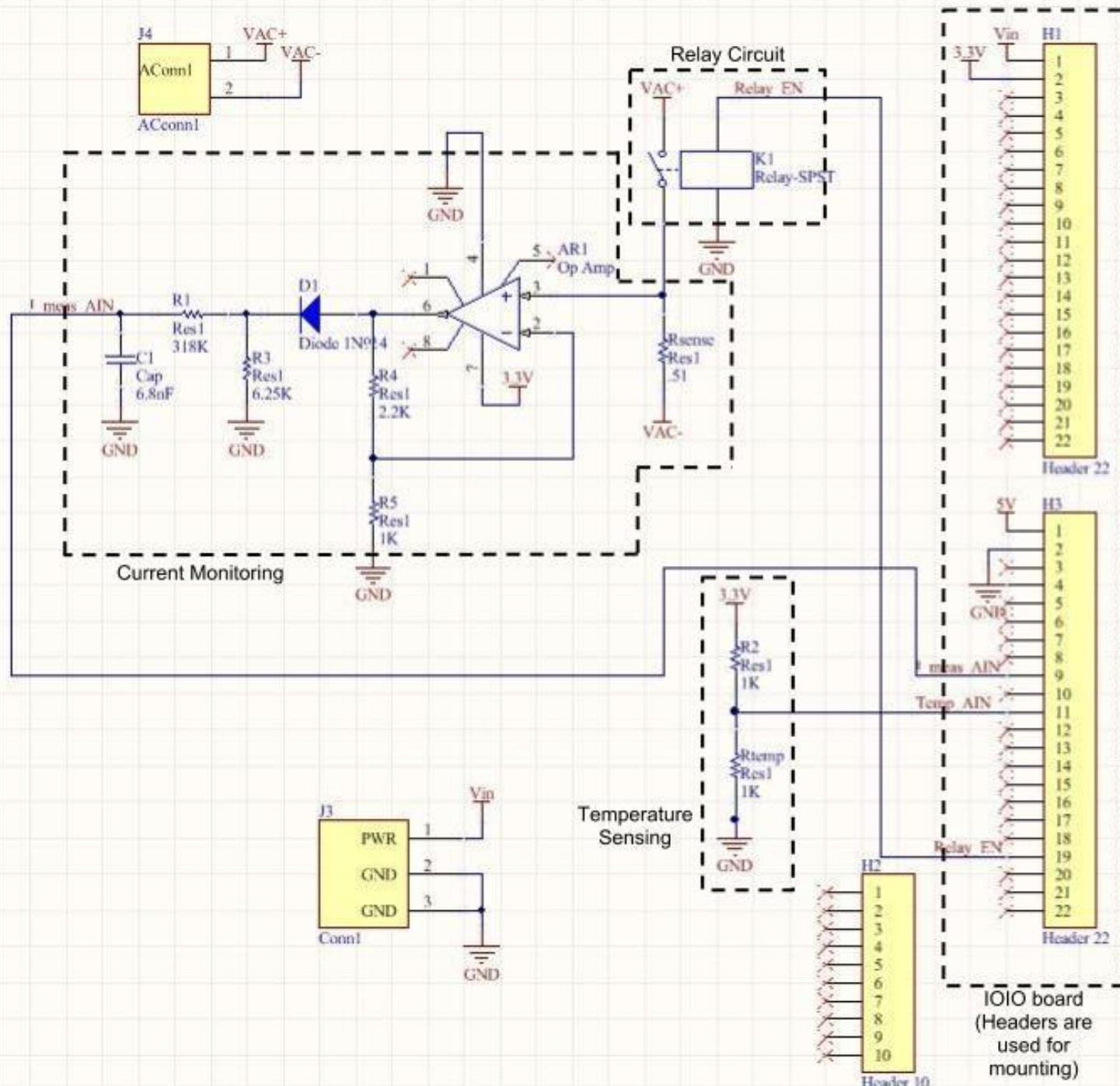
- Arduino board
 - Arduino Uno
 - Arduino Mini
 - IOIO*
- On/Off control
 - Triac
 - Mechanical relay
 - Solid state relay*
- Current monitoring
 - Current transformer
 - Shunt resistor with differential amplifier*

*Indicates the selected method



Current Hardware Design

- IOIO board
 - Arduino-powered dev board
 - Android interfacing capabilities
- Relay circuit
 - On/off control
 - Driven by micro digital output
- Current monitoring
 - Samples AC waveform across shunt resistor
 - Interfaces to micro A/D input
- Temperature monitoring
 - Samples thermistor divider network
 - Interfaces to micro A/D input

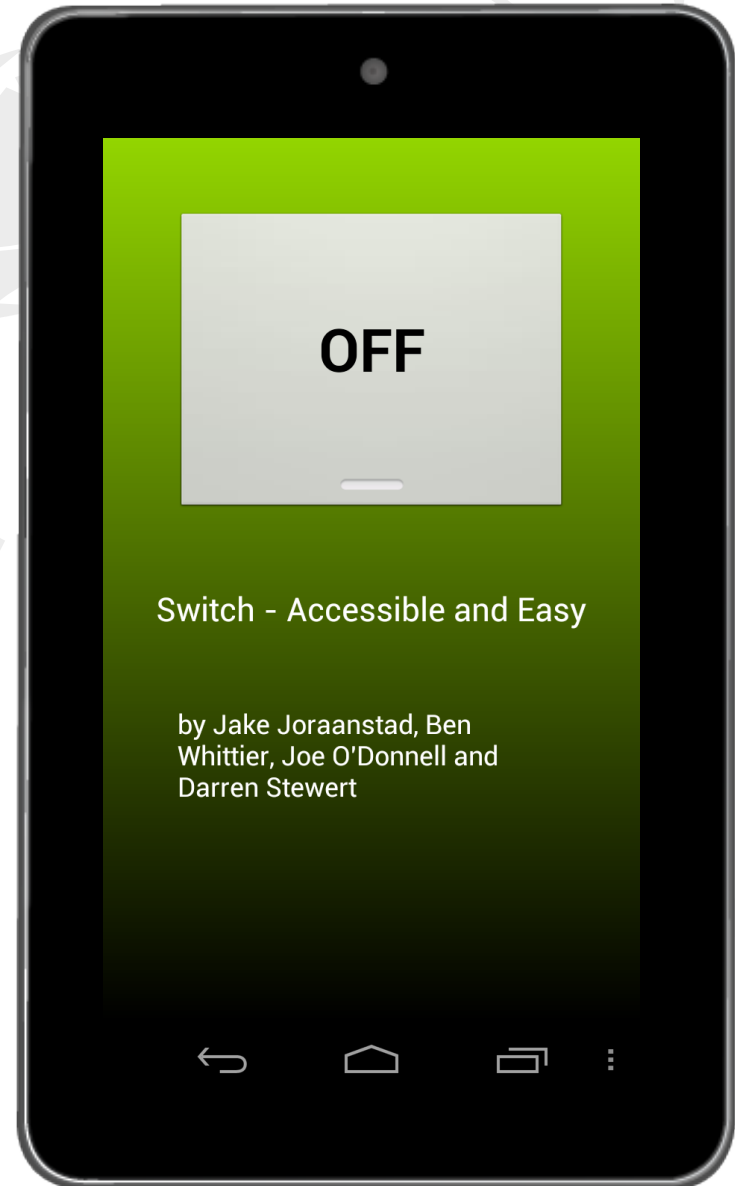


SmartSwitch App

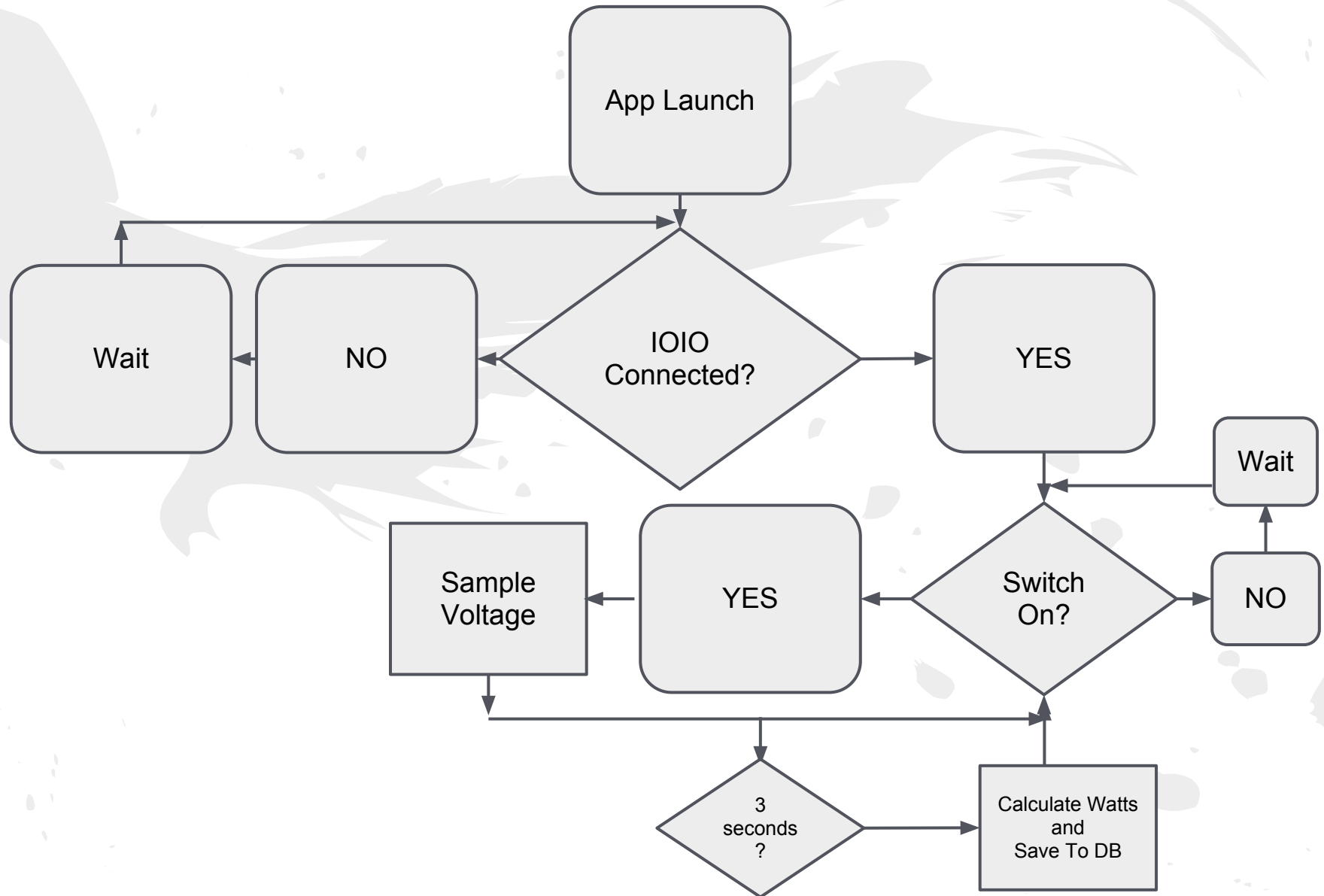
This application runs the algorithms which:

- Samples and records data
- Calculates and synchronizes data to the Switch cloud database
- Controls the on/off functionality

This application is installed on the local Android device attached to the SmartSwitch via USB



SmartSwitch App - Flow Chart



SmartSwitch App Code - User Interface

```
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
```

```
    android:layout_width="match_parent"  
    android:layout_height="match_parent"  
    android:background="@drawable/main_background"  
    android:orientation="vertical" >
```

```
<ToggleButton
```

```
    android:id="@+id/button"  
    android:layout_width="fill_parent"  
    android:layout_height="200dp"  
    android:layout_margin="50dp"  
    android:text="ToggleButton"  
    android:textSize="40dp"  
    android:textStyle="bold" />
```

```
<TextView
```

```
    android:id="@+id/textView1"  
    android:layout_width="wrap_content"  
    android:layout_height="wrap_content"  
    android:layout_gravity="center"  
    android:text="@string/switchTitle"  
    android:textAppearance="?android:attr/textAppearanceLarge" />
```

```
<TextView
```

```
    android:id="@+id/textView2"  
    android:layout_width="match_parent"  
    android:layout_height="wrap_content"  
    android:layout_gravity="center_horizontal"  
    android:padding="50dp"  
    android:text="@string/bySwitch"  
    android:textAppearance="?android:attr/textAppearanceMedium" />
```

```
</LinearLayout>
```

SmartSwitch App Code - IOIO Service

```
if (wasOn != isOn && isOn == true)
    //this has gone from off to on
    {
        voltsParse = new ParseObject("Volts");
        currentTime = System.currentTimeMillis();
    }
else if (wasOn != isOn && isOn == false)
    {
        voltsParse = new ParseObject("Volts");
    }

if (isOn == true)
    {
        volts = voltsIn.getVoltage();
        voltOnArray.add(volts);
    }
else if (isOn == false)
    {
        volts = voltsIn.getVoltage();
        voltOffArray.add(volts);
    }
```

SmartSwitch App Code - Calculate and Save

```
//convert voltage and time to watts
```

```
if (isOn == true)
```

```
{
```

```
    //Calculation specified by Ben based our resistor the voltage is being measured across
```

```
    vRms = 120 - changeInVolts/.707;
```

```
    amps = changeInVolts/.51;
```

```
    watts = amps * vRms;
```

```
    wattsArray.add(watts);
```

```
}
```

```
//Save to database
```

```
public void sendVoltageToParse(ParseObject voltsToParse) {
```

```
    voltsToParse.saveEventually();
```

```
    Log.i("startAgain:", "Called after saveEventually");
```

```
    createIOIOLooper();
```

```
    Log.i("startAgain:", "Should Run Looper");
```

```
}
```

```
};
```

Software - Mobile Controller

This application can run on any Android phone or tablet

Gives user control of the SmartSwitch from anywhere in the world via a simple toggle button

Similar software development functions and UI



Website - Summary

SwitchIncorporated.com

- Clean and straightforward

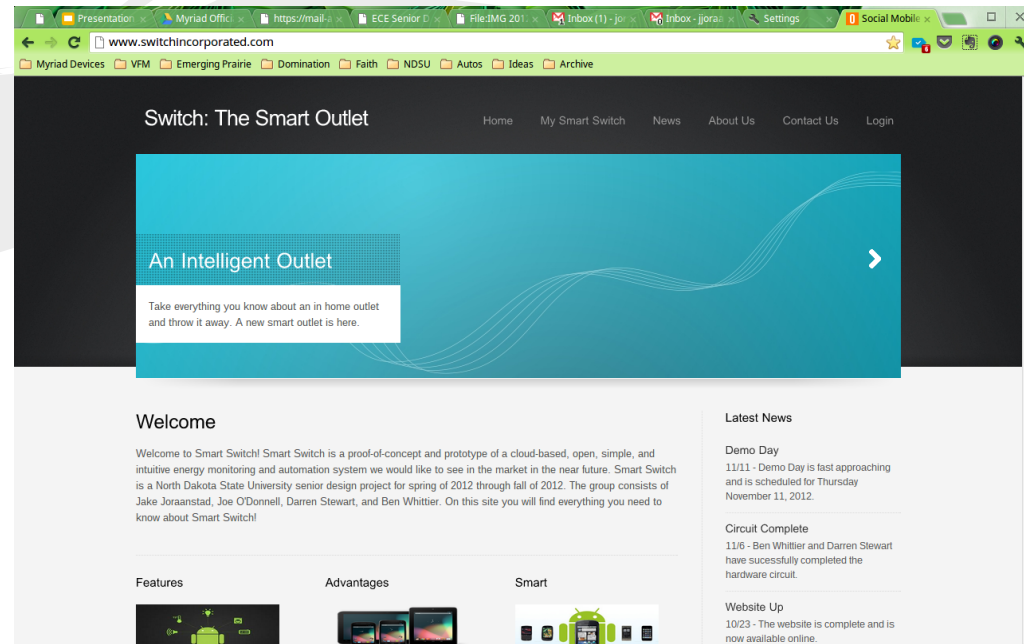
Our website provides

- SmartDash
- Latest data
- Contact Us
- News

Built with

- HTML5/CSS3
- Javascript
- Adobe Photoshop

Retrieves data from Parse.com using Parse SDK.



Website - Technical

● Push Notifications

// Call Push.send function from Parse Library

```
Parse.Push.send({
```

```
  channels: [ "" ], // Use blank channel
```

```
  data: {
```

```
    action:
```

```
    "ioio.examples.hello_service.UPDATE_STATUS"
```

```
  }
```

```
}, {
```

```
  success: function() {
```

```
    // Push was successful
```

```
    document.getElementById("1").value="ON";
```

```
  },
```

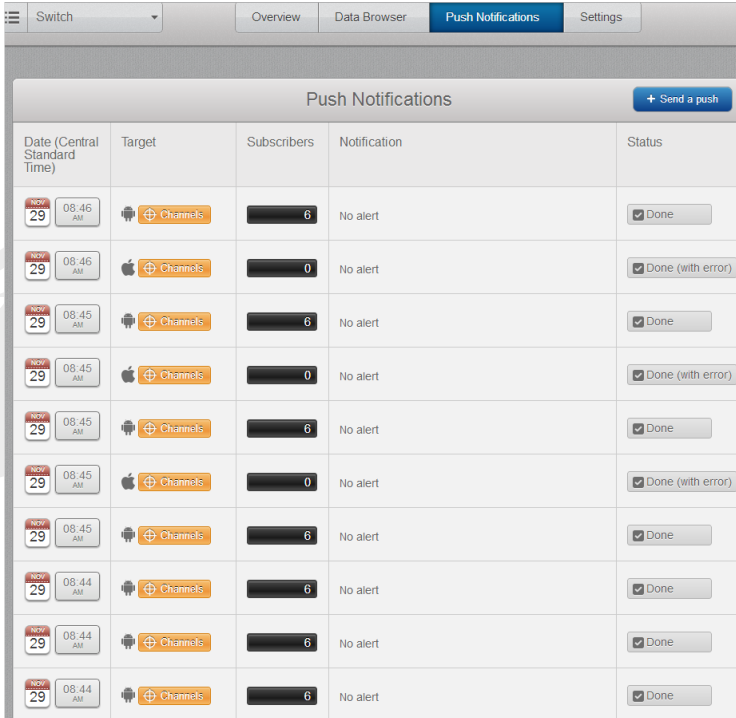
```
  error: function(error) {
```

```
    // Push failure
```

```
    document.getElementById("1").value="ERROR!";
```

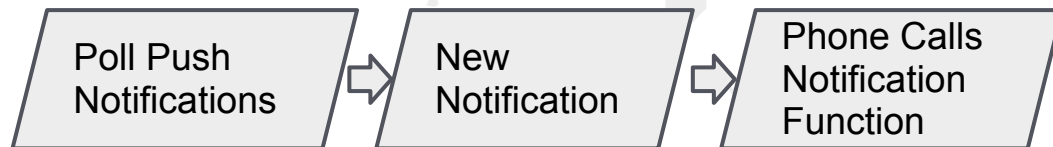
```
  }
```

```
});
```



The screenshot shows the Parse Push Notifications interface. At the top, there are tabs for 'Switch', 'Overview', 'Data Browser', 'Push Notifications' (selected), and 'Settings'. Below the tabs is a 'Push Notifications' section with a '+ Send a push' button. The main area contains a table with the following columns: 'Date (Central Standard Time)', 'Target', 'Subscribers', 'Notification', and 'Status'. The table lists 10 notification attempts, each with a date, time, target (Android or Apple), subscriber count, notification message ('No alert'), and a status (e.g., 'Done', 'Done (with error)').

Date (Central Standard Time)	Target	Subscribers	Notification	Status
NOV 29 08:46 AM	Android Channels	6	No alert	Done
NOV 29 08:46 AM	Apple Channels	0	No alert	Done (with error)
NOV 29 08:45 AM	Android Channels	6	No alert	Done
NOV 29 08:45 AM	Apple Channels	0	No alert	Done (with error)
NOV 29 08:45 AM	Android Channels	6	No alert	Done
NOV 29 08:45 AM	Apple Channels	0	No alert	Done (with error)
NOV 29 08:45 AM	Android Channels	6	No alert	Done
NOV 29 08:44 AM	Android Channels	6	No alert	Done
NOV 29 08:44 AM	Android Channels	6	No alert	Done
NOV 29 08:44 AM	Android Channels	6	No alert	Done

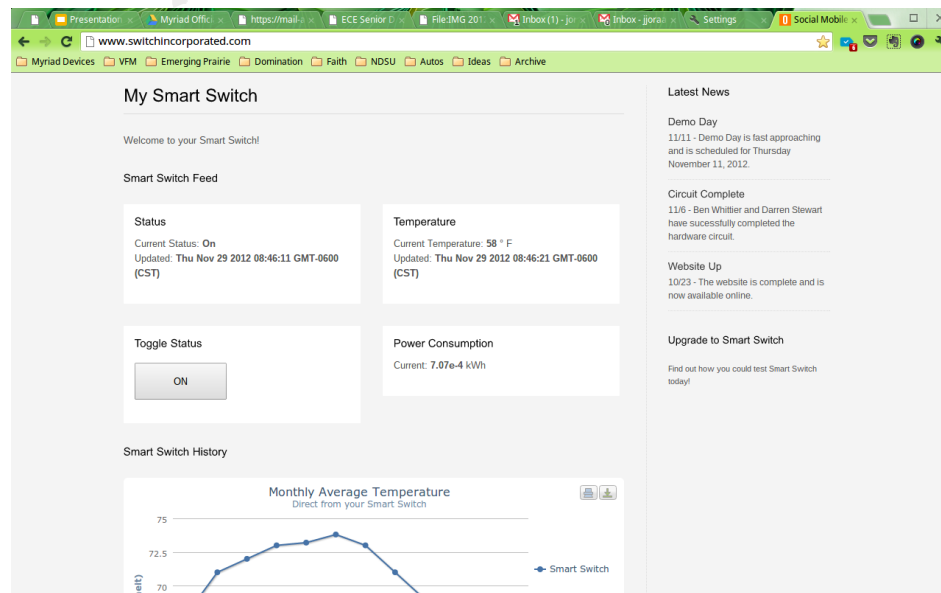


Website - Technical

● Retrieving Data from Database

```
Parse.initialize(""); // Link webpage to our database
var Volts = Parse.Object.extend("Volts");
var query = new Parse.Query(Volts);
query.descending("createdAt");
query.find({
  success: function(results) {
    // Success
    ArraySize = results.length - 1;
    // Record values
    LatestTemp = results[0].get("temp").toPrecision(2);
    LatestkWh = results[0].get("kWh").toExponential(2);
    LatestTime = results[0].createdAt;
    // Display
    document.getElementById("CurrentkWh").innerHTML
    = LatestkWh;
    document.getElementById("CurrentTemp").
    innerHTML = LatestTemp;
    document.getElementById("CurrentDate").innerHTML
    = LatestTime;
  },
  error: function(error) {
    alert("Error: " + error.code + " " + error.message);
  }
});
```

objectid	String	kWh	Number	temp	Number	createdAt	Date	updatedAt	Date	ACL
s0SyR7X3Er		0.000707486867737...		58.104852762207884		Thu, 29 Nov 2012 14:46:21 GMT		Thu, 29 Nov 2012 15:14:16 GMT		(em)
HBm59euU2		0		58.11691095249216		Thu, 29 Nov 2012 14:45:49 GMT		Thu, 29 Nov 2012 14:46:10 GMT		(em)
1yz0Dasu1		0.000005099654510...		56.13030277606066		Thu, 29 Nov 2012 14:45:37 GMT		Thu, 29 Nov 2012 14:45:37 GMT		(em)
zUKsijPkm		0		56.2389253450047		Thu, 29 Nov 2012 14:45:15 GMT		Thu, 29 Nov 2012 14:45:27 GMT		(em)
EyEhRZCsdt		0.000005049888909...		56.24090931886667		Thu, 29 Nov 2012 14:45:06 GMT		Thu, 29 Nov 2012 14:45:06 GMT		(em)
0jlp9WvYL		0		56.14815854081854		Thu, 29 Nov 2012 14:44:52 GMT		Thu, 29 Nov 2012 14:44:52 GMT		(em)
3Z4GHVY3i0		0		56.11939091981969		Thu, 29 Nov 2012 14:44:41 GMT		Thu, 29 Nov 2012 14:44:41 GMT		(em)
XKPwdY9Lra		0		56.13179075645712		Thu, 29 Nov 2012 14:44:30 GMT		Thu, 29 Nov 2012 14:44:30 GMT		(em)
K2to1jmamL		0.000008908323021...		56.10748707664777		Thu, 29 Nov 2012 14:43:57 GMT		Thu, 29 Nov 2012 14:44:19 GMT		(em)
u0GCH3HUu		0.000106542354986...		59.41576349151899		Thu, 29 Nov 2012 14:43:26 GMT		Thu, 29 Nov 2012 14:43:43 GMT		(em)
N3qG1EAP7		0		67.92750735292901		Thu, 29 Nov 2012 14:43:24 GMT		Thu, 29 Nov 2012 14:43:25 GMT		(em)
TGY82bZUI		0		75.53455913327082		Thu, 29 Nov 2012 14:43:23 GMT		Thu, 29 Nov 2012 14:43:23 GMT		(em)
4cMDdmBc0		0.000004680423453...		10.395700613975691		Thu, 29 Nov 2012 14:33:56 GMT		Thu, 29 Nov 2012 14:33:56 GMT		(em)
9LkCjK49e		0.000002996071342...		6.990209479866849		Thu, 29 Nov 2012 14:33:53 GMT		Thu, 29 Nov 2012 14:33:53 GMT		(em)
H3Siz2FpKa		0		105.74654979913242		Wed, 28 Nov 2012 05:31:35 G...		Thu, 29 Nov 2012 14:33:52 GMT		(em)
jpxvUTbNK		0		89.52805947081549		Wed, 28 Nov 2012 05:27:01 G...		Wed, 28 Nov 2012 05:31:24 G...		(em)
Z7XMirikGS		0		80.65618765800247		Wed, 28 Nov 2012 05:26:39 G...		Wed, 28 Nov 2012 05:26:39 G...		(em)
MfmeYlMs3		0		80.32238405572235		Wed, 28 Nov 2012 05:26:15 G...		Wed, 28 Nov 2012 05:26:27 G...		(em)
ZLZOJXWYHd		0		79.94840498273692		Wed, 28 Nov 2012 05:26:04 G...		Wed, 28 Nov 2012 05:26:04 G...		(em)
4Rsal1owu7		0		79.613111340006034		Wed, 28 Nov 2012 05:25:53 G...		Wed, 28 Nov 2012 05:25:53 G...		(em)



Testing and Evaluation

Control of SmartSwitch

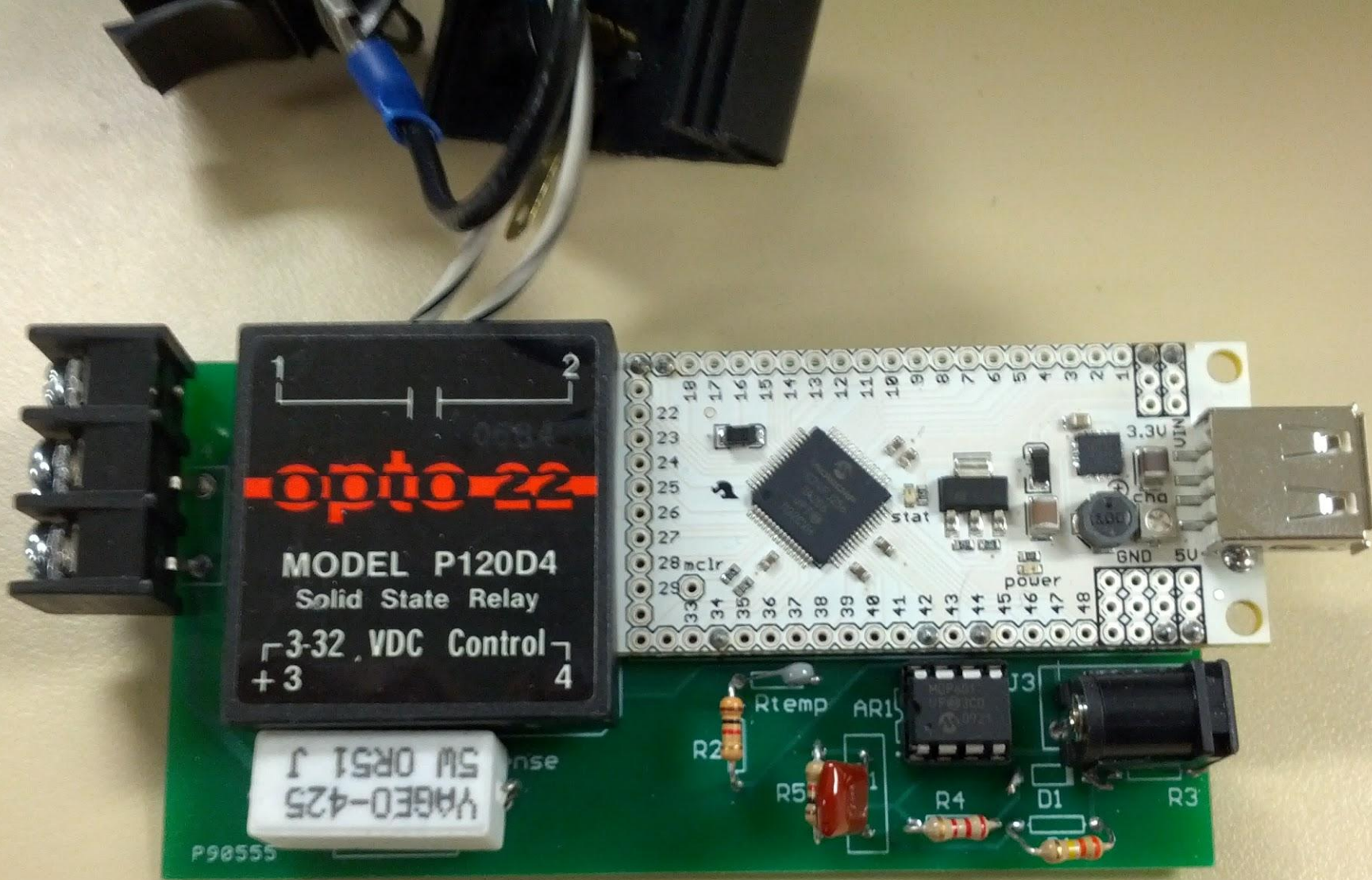
- Website
 - Created at times
 - Latest data reported and properly synced
- Hardware
 - Tested controlling (on/off) a light plugged into SmartSwitch on different outlets in two different buildings
 - Saw results were consistent

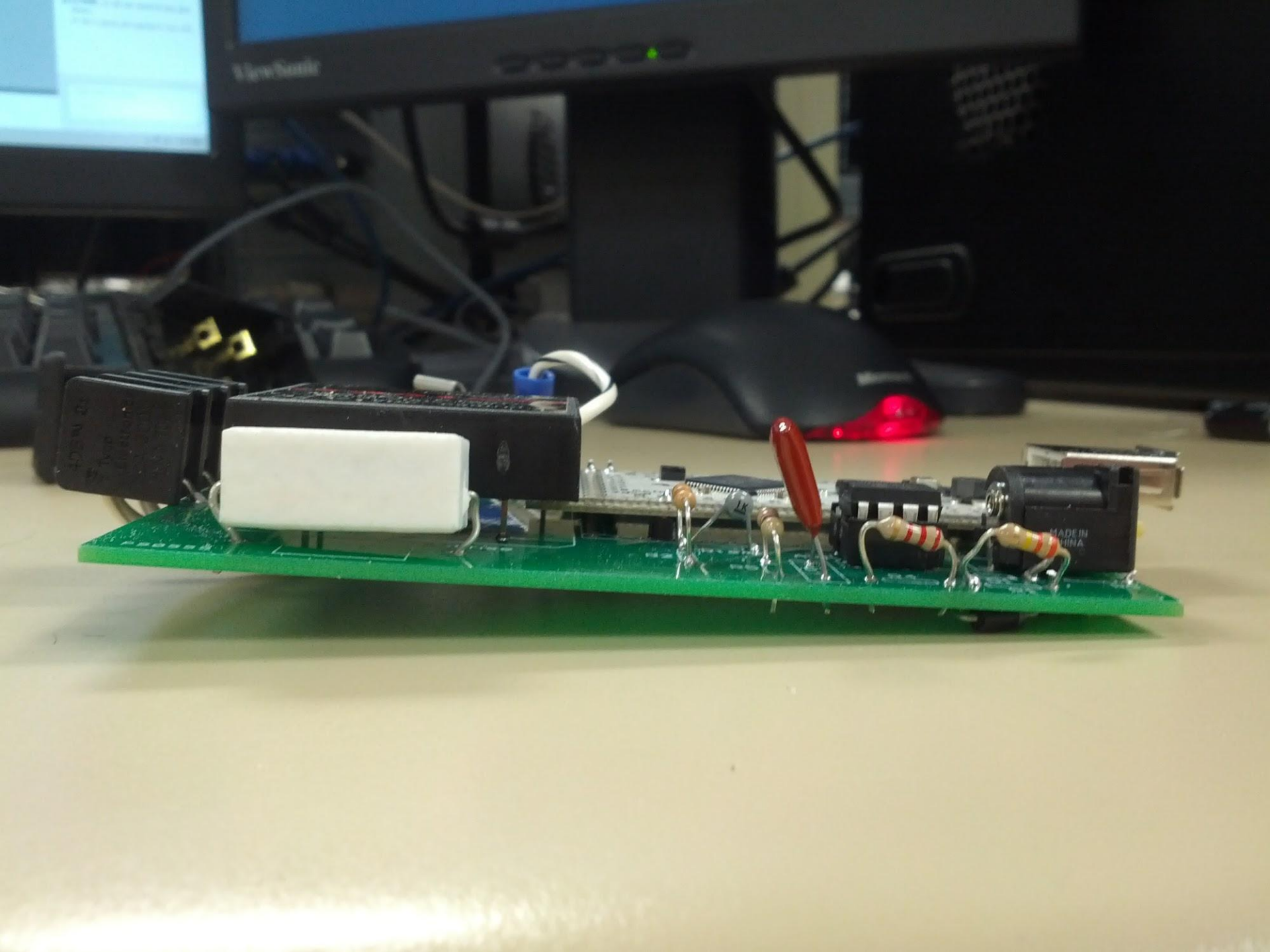
Current monitoring

- Software
 - Adjustments required for data conversion due to inconsistent AC noise
- Hardware
 - Observed sampled current monitoring waveform under same two conditions as on/off testing
 - Some differences seen in amplitude of waveform due to noise on neutral line of the AC terminal
 - Applied different wattage bulbs



Pictures











NETGEAR
Switching Adapter
Model: SWA1000
FCC ID: A50000
CE Mark
RoHS Compliant

ON

Switch - Accessible and Easy

by Jake Joraenstad, Ben
Whittier, Joe O'Donnell
and Darren Stewart

My Smart Switch

Welcome to your Smart Switch!

Smart Switch Feed

Status

Current Status: **On**

Updated: **Thu Nov 29 2012 08:46:11 GMT-0600 (CST)**

Temperature

Current Temperature: **58 ° F**

Updated: **Thu Nov 29 2012 08:46:21 GMT-0600 (CST)**

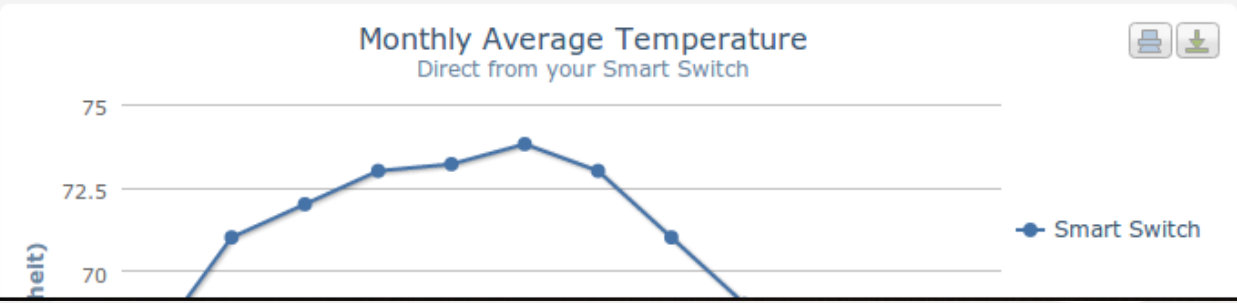
Toggle Status

ON

Power Consumption

Current: **7.07e-4 kWh**

Smart Switch History



Latest News

Demo Day

11/11 - Demo Day is fast approaching and is scheduled for Thursday November 11, 2012.

Circuit Complete

11/6 - Ben Whittier and Darren Stewart have sucessfully completed the hardware circuit.

Website Up

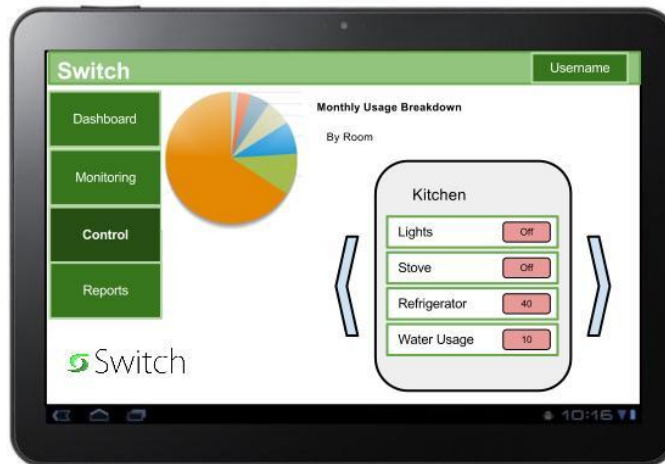
10/23 - The website is complete and is now available online.

Upgrade to Smart Switch

Find out how you could test Smart Switch today!



Switch



Problems Encountered

- Hardware: PCB (first rev)
 - Vias too small
 - PCB too large
 - Headers were defined backwards in PCB layout, IOIO connected to wrong nets
- Hardware: Designing Enclosure
- Software: Java and Javascript
 - HTML not syncing with Javascript functions
 - Push notification calling service function
 - Understanding "threading" in Android
 - Reaching out to the community for help
 - Overcoming not being experienced in advanced high level software development

Lessons Learned

- Hardware: PCB
 - Double, triple, and quadruple check every aspect of the design before ordering - pay great attention to detail
- Software: Java and Javascript
 - Use Parse.com SDK query functions instead of retrieving objects
 - Sort query results from database before using them
 - Utilize threading in Android as it allows for smooth transitions and for making multiple calculations while taking data
 - Jake is better off paying others to do software as it takes him forever to build applications

Budget

Part	Qty	Unit Cost	Total Cost (True Value)	Acquired Cost
Current transformer	2	3.75	7.50	7.50
AC/DC converter	1	3.00	3.00	3.00
IOIO board	3	49.95	149.85	149.85
Triac	2	1.77	3.54	3.54
1:1 Transformer	1	3.00	3.00	3.00
Diodes	2	0.01	0.02	0.00
Resistors	4	0.002	0.008	0.00
Capacitors	2	0.002	0.004	0.00
USB cable	1	3.00	3.00	3.00
Droid Incredible phone	1	50.00	50.00	50.00
Thermistor	1	0.01	0.01	0.00
Solid state relay	1	2.60	2.60	0.00
Opamp	1	0.15	0.3	0.00
PCB	2	33.00	66.00	66.00
Power outlet (NEMA)	4	0.93	3.72	3.72
Pre-fabricated Enclosure	3	4.90	14.70	14.70
Post-functional Enclosure	1	ECE inventory	N/A	0.00
Total			307.25	304.31

Future Uses

Cheap Smart Outlet

- Potentially be produced at a much lower cost, possibly under \$50
- Reduced to half the size of our existing unit
- Use open-source IOIO board design documents (schematic, layout, etc.) to design all components to be placed on one PCB and drive down cost

Integrate with SmartThings

- Potentially work with the new cloud based startup out of Minneapolis to enable control of SmartSwitch from the SmartThings dashboard



Summary

- We used HTML and Javascript to make a website that completely worked. The website is hosted on a cloud server and gathers up-to-date information from our database from Smart Switch. The website is also able to send on and off push notifications to the database which SmartSwitch in turn correctly uses.
- We developed a fully functioning PCB that can control AC current flow to any load connected and monitor the current flow when the relay is engaged. The microcontroller that interfaces with the hardware communicates to the Android device via USB. This is where all of the user input, data processing, and data syncing to the cloud is performed.
- The enclosure fully contains all of the hardware (excluding the AC to DC converter) and firmly mounts to any standard wall outlet.





And Shaboom.

We're done.

Any Questions?

